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The percentage of infection found among the 709 specimens of *A. quadrimaculatus*, namely, 2.4, appears to be fairly constant in all our field dissections thus far conducted.

TABLE 2.—*Descriptions of the extent of infection in the specimens of A. quadrimaculatus.*

Specimen No.	Date dissected.	Infected stomach wall.	Salivary gland sporozoites.
1	Aug. 27.....		1 lobe infected slightly.
2	Aug. 28.....		2 lobes infected; 1 slightly, 1 moderately.
3	Sept. 1.....	A single oocyst presporoblastic without pigment.	
4	Sept. 7.....	7 oocysts in young stages of development; pigment present.	
5	Sept. 13.....	3 oocysts presporoblastic.....	
6	Sept. 22.....		2 lobes of 6 heavily infected.
7	Oct. 6.....		1 lobe infected slightly.
8	do.....		4 lobes, moderate infection.
9	do.....		2 lobes, moderate infection.
10	do.....		1 lobe, heavily infected.
11	Oct. 7.....		6 lobes, moderate infection.
12	Oct. 8.....		6 lobes with numerous sporozoites.
13	do.....		4 lobes, scanty infection.
14	Oct. 11.....		6 lobes, moderate infection.
16	Oct. 12.....		2 mid lobes, scant infection.
17	Oct. 15.....		6 lobes, moderate to heavy infection.
18	Oct. 20.....		4 lobes, moderate infection.

ANOPHELES CRUCIANS WIED. AS AN AGENT IN MALARIA TRANSMISSION.

By C. W. Merz, Ph. D., Special Investigator, United States Public Health Service.

So far as the writer is aware there is little published evidence upon which to judge the importance of *Anopheles crucians* Wied. as a vector of malaria in nature. The species is known to be a suitable host for the parasite of æstivo-autumnal and tertian malaria (Mitzmain, 1916 (a), (b)) and to transmit at least the former type under laboratory conditions (Mitzmain 1916 (a), King 1916), but no available literature records the finding of infected specimens in nature. Beyer and his coworkers and Dupree are reported by various authors to have found cases of this sort, but the reports are, according to King (1916), based upon a misinterpretation of the statements of these investigators.

Epidemiological considerations and observations on the habits of *crucians* have led to indefinite conclusions. According to King the incrimination of *crucians* by Beyer and his associates was based upon epidemiological findings. On the other hand the apparent absence of any marked tendency on the part of *crucians* to enter dwellings has argued against its efficiency as a vector. It may be considered a relatively open question, therefore, whether *crucians* is or is not of practical importance—certainly the question is not yet settled.

In arriving at a conclusion in this case it is of primary importance to determine the relative frequency with which *crucians* bites man under conditions suitable for malaria transmission. The present

paper is concerned largely with this determination. Obviously, the best criterion for the purpose is the finding of infected specimens of *crucians* in nature, and most of the accompanying observations deal with this phase of the matter, although other data are considered.

After these observations were made, it was learned that a case of natural infection of *crucians* had been found in 1917 by Bruce Mayne, at Monroe, La. Gland sporozoites were observed in this infected specimen of *crucians*.

Observations on Habits of *Anopheles crucians*.

In a previous paper (Metz 1918, Table I) the writer has recorded the types of hiding places selected by 634 specimens of *crucians* taken in connection with an experiment to determine the range of flight. Although much larger numbers have been taken at other times, these records are significant because, in obtaining them, a thorough search was made of all available hiding places. The buildings consisted mainly of houses and sheds, with a few stables and privies and one or two pigpens. The results are summarized as follows: Under houses 415, inside houses 2, in stables 111, in pigpens 25, in privy 1, in sheds 45, under bridges 35. These observations all apply to one locality—outskirts of Montgomery, Ala., on the west.

Subsequently more extended observations were made in Polk County, Fla., where *Anopheles crucians* and *quadrimaculatus* intermingle in varying proportions. Here it was possible to make a fairly accurate comparison of the relative tendency of the two species to enter buildings frequented by man. In each case the proportions depended largely upon the relative abundance of the respective species, but the evidence was so consistent throughout there could be no doubt as to the general conclusion. The number of *crucians* found in dwellings as compared with the number found elsewhere (as underneath houses, in privies and other outbuildings) was always small, while with *quadrimaculatus* the situation was reversed. However, in privies *crucians* was almost as numerous, on the average, as was *quadrimaculatus*.

The finding of *crucians* in such large numbers underneath dwellings suggested (as similar observations on *punctipennis* have suggested with respect to that species, Carter, Le Prince and Griffiths, 1916) that they might have the habit of entering the dwellings during the night and flying out again in the morning. To test this, window traps were installed in a dwelling located in a region heavily infested with *crucians*. Less than half a dozen specimens were taken in two weeks' time, making it very probable that no considerable flight into the house took place.

These observations would tend to give *crucians* a relatively unimportant place in malaria transmission when compared with *quadrimaculatus*. On the other hand, certain localities have been found in

which *crucians* was the predominant *Anopheles*—almost to the exclusion of the others—and in which malaria appeared to be prevalent. One such locality is that near Montgomery, Ala. (Metz 1918). A history index of this area made by the Public Health Service during the winter of 1917–18 reported a high malaria rate during the preceding year. Similarly, in Florida the writer has found at least two places in which malaria was said ¹ to be prevalent in localities found to be infested with *crucians* but practically free from other *Anopheles*.

Relative Percentage of Infectivity of *Anopheles crucians* and *Anopheles quadrimaculatus*.

Although the above observations all bear more or less directly on the question under consideration, more explicit information is needed. For this reason an attempt was made to secure exact data on the relative number of infected specimens of *crucians* and *quadrimaculatus* present under natural conditions in a given region (Polk County, Fla.)². Both species were collected and examined in as large numbers as practicable. They were taken from several localities, mostly in or near Mulberry, Fla., and in the rural districts within 10 miles of Lakeland, Fla. Altogether, 1,757 specimens were examined, but many of these were from localities in which no infection was found. Leaving the latter out of account the results are as follows:³

	Number exam- ined.	Infected.	Not infected.	Per cent infected.
<i>Anopheles crucians</i>	379	2	377	1.188
<i>Anopheles quadrimaculatus</i>	423	4	419	1.105

Considering the small number of infected specimens and the large mathematical probable error resulting therefrom, the ratio given can be no more than an approximation, but it indicates a probability that the percentage of infected specimens was approximately the same in both species.

It may be of interest to note, in the case of the infected specimens mentioned above, that the amount of infection in the individual mosquito was greater in *quadrimaculatus* than in *crucians*. Neither of the two specimens of *crucians* showed more than a dozen oocysts on the stomach wall, whereas three of the four infected *quadrimaculatus* possessed at least four times that many, one of them exhibiting more than 200 oocysts.

¹ Reports of physicians and patients.

² So far as known *A. punctipennis* does not occur in this region.

³ The criterion used in determining infection in these cases was the presence of oocysts on the stomach wall. The salivary glands were also examined in the cases that revealed oocysts on the stomach. In all but one of them, however, the glands appeared to be free from sporozoites. The exception was a specimen of *quadrimaculatus*.

These observations were made during the fall and early winter—September to December—the infected specimens being taken on the following dates: September 15, October 15, 26, and 30, November 23, and December 4. The most heavily infected specimen was taken on the last-mentioned date. No marked lessening in the amount of infection was observed as the season advanced and the weather became cooler—possibly because the temperature, even in December, averaged over 60° F. (average maximum 73°, average minimum 52°, lowest extreme 41°).

All of the infected specimens were taken near dwellings, and probably most of them were taken in or underneath dwellings, for most of the collecting was done in those places. The exact point of capture is known for only two of the six. Of these, one (*crucians*) was taken in a pigpen about 200 feet from the nearest dwelling, in which, however, there was reported to be no malaria; the other (*quadrinaculatus*) was taken in a privy near several negro houses where malaria was prevalent.

Conclusions.

It is believed that the data given above leave no doubt as to the susceptibility of *Anopheles crucians* to infection with malaria plasmodia under natural conditions. Likewise, they indicate that, although the habits of this species are probably less conducive to natural infection than are those of *quadrinaculatus*, nevertheless a considerable amount of infection occurs. This evidence of *crucians*' susceptibility of infection in nature, taken in conjunction with the demonstration of its infectivity; i. e., its rôle as a vector, under laboratory conditions (Mitzmain, 1916 (a), King, 1916), would indicate that this species is potentially of definite sanitary importance. The evidence is too meager, however, to indicate the degree of importance it merits as compared with *quadrinaculatus* and *punctipennis*.

Considering its habits, it seems probable that *crucians* is primarily an out-of-door biter; i. e., it is probably most effective on porches and in outhouses. If such proves to be the case, especial precautions against out-of-door exposure in the evening will be necessary in *crucians* infested districts, whereas screening of dwellings will be relatively unimportant except where other species must also be considered.

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